Carpal tunnel syndrome: modern diagnostic and management techniques

Nabil Kanaan and R A Sawaya

SUMMARY

Carpal tunnel syndrome is a common disorder characterised by the classical symptoms of numbness and paraesthesiae along the distribution of the median nerve. Thenar muscle weakness is a late manifestation of advanced disease. Tinel's and Phalen's signs are helpful in suggesting the diagnosis. The symptoms and signs arise from entrapment of the median nerve. Electrophysiological tests are helpful in confirming the diagnosis and magnetic resonance imaging may be used in the diagnosis of atypical cases. Ergonomic manoeuvers and steroid injections may alleviate symptoms in mild cases. Surgery is reserved for severe cases and those who do not respond to conservative therapy. Open carpal tunnel release is the classical surgery with usually excellent results. Endoscopic carpal tunnel release surgery was introduced to decrease the morbidity of open surgery. This latter technique also has its complications and is still being refined.

Keywords: *carpal tunnel syndrome; diagnosis.*

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Submitted: 6 December 1999; Editor's response: 24 February 2000; final acceptance: 27 October 2000.

Introduction

CARPAL tunnel syndrome (CTS) is a common disorder in general medical practice. It arises from compression of the median nerve between the transverse carpal ligament (CL), also called the flexor retinaculum, superiorly, and the flexor tendons (flexor digitorum superficialis, flexor digitorum profundus, flexor pollicis longus), and carpal bones (scaphoid and trapezium) inferiorly.

Anatomically, the fibres that form the median nerve originate from the fifth, sixth, seventh, and eighth cervical roots, and the first thoracic root and pass through the lateral and medial cords of the brachial plexus. The motor branch innervates the abductor pollicis brevis, opponens pollicis, and the two lateral lumbricals in the hand. The sensory branch innervates the volar aspect of the lateral three digits and the lateral half of the fourth digit extending to the palm and the distal dorsal aspects of these digits beyond the distal interphalangeal joints[1] (Figure 1).

Clinical features

Carpal tunnel syndrome is more common in females than males, with a ratio of seven to three. Although it is more prevalent between the fourth and sixth decades, it occurs in all age groups.

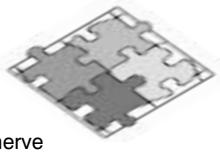
The clinical presentation of CTS is variable. Most patients complain of aching, burning, tingling or numb sensations in the hand localised to the first three digits and the lateral aspect of the fourth digit, with occasional involvement of the plantar aspect of the hand. Symptoms are typically worse at night, are exaggerated by strenuous wrist movements, and become persistent as the entrapment worsens.[2,3]

With the progression of the disease symptoms may radiate proximally to the forearm, elbow, arm, and shoulder. Weakness in hand grip and opposition may become apparent and the disease may be mistaken for cervical radiculopathy, shoulder bursitis, thoracic outlet syndrome, transient ischaemic attack, coronary artery ischaemia, tendinitis, fibrositis or lateral epicondylitis.[1,4,5]

The physical examination involves studying the motor and sensory functions of the affected nerve in comparison to those of the ipsilateral ulnar nerve. The Tinel's sign (percussion of the median nerve at the level of the carpal creases to reproduce the paraesthesiae in the median nerve dermatom) and Phalen's sign (holding the wrist at maximum flexion for 30 to 60 seconds to reproduce paraesthesiae in an already compromised nerve) are two provocative tests to study entrapment of the median nerve.[2,3]

The severity and specificity of the clinical picture and the provocative tests differ from one study to another. One study suggested that Tinel's sign, and not Phalen's sign, correlated significantly with the abnormal electrophysiological para-

HOW THIS FITS IN



What do we know?
CTS is a well recognised condition. Diagnostic techniques have traditionally involved the physical examination and nerve condition studies. Classical management generally centred on conservative as well as open release surgery.

What does this paper add?
Modern techniques of diagnosis are discussed, including the MRI. New modes of surgery are also discussed, including endoscopic release.

Figure 1. Sensory innervation of the median nerve in the hand.

Table 1. Median motor nerve conduction studies.

	Normal	Mild CTS	Severe CTS
Distal latency (milliseconds)	3.4	5.1	7.8
Amplitude (millivolts)	8.2	3.9	2.3
Conduction velocity (ms^{-1})	55	48	36

meters.[6]

Another study suggested that the clinical features of CTS were more specific (66–87%) than sensitive (23–69%) for CTS.[7] Moreover, weakness in the abductor pollicis brevis was more sensitive than hyperaesthesia in the median innervated dermatom (66 and 50% respectively). On the other hand, Phalen's sign, when positive for CTS, had a specificity of 75% and a sensitivity of 50%, while Tinel's sign had a sensitivity of only 23%.[7] Our opinion is that the motor and sensory symptoms, signs, and history are more important and reliable than Phalen's and Tinnel's signs in the diagnosis of CTS.

Aetiology

In carpal tunnel syndrome the volume of the contents of the carpal tunnel is increased. Gelberman *et al* demonstrated that the carpal tunnel pressure in normal controls averages 3 mmHg compared with 32 mmHg in patients with carpal tunnel syndrome, with the wrist in a neutral position.[8] The pathophysiology of the nerve lesion is ischaemic with the compression of the vasa nervosum secondary to the increased pressure.[9]

A predisposing factor for entrapment may be repetitive wrist motion as occurs with activities such as knitting, typing, scrubbing, dishwashing, driving, painting, and gardening. This is deduced from the clinical experience of physicians dealing with this syndrome rather than a systemic study.

Some medical conditions are associated with carpal tunnel syndrome. These include pregnancy, lactation, menstrual cycles, oral contraceptive use, menopause, diabetes mellitus, pyridoxine deficiency, toxic shock syndrome, chronic haemodialysis, osteoarthritis of the carpal bones, rheumatoid arthritis, obesity, amyloidosis, mucolipidosis, chondromalacia, myxoedema, acromegaly, congenitally small carpal tunnel, and athetoid dystonic cerebral palsy.[5] These conditions are usually diagnosed much earlier than CTS and thus the aetiology of the latter would have already been established.

Conditions that may lead to an increase in the volume of the carpal tunnel contents include persistent median artery, aneurysm or arterio-venous malformation, anomalous muscles or tendons, infections, haemorrhage, congenitally small carpal tunnel, neurofibroma, haemangioma, lipoma, ganglion, xanthoma, and gouty tophi.[5]

These medical conditions are very rare. They may be suspected when the above mentioned predisposing factors and diseases are absent and when the patient fails conservative therapy for CTS. Since the treatment of CTS will then be surgery, prior investigation for the cause of the entrapment may not be necessary and the aetiology will be revealed intraoperatively.

Diagnostic studies

Electrophysiological tests

Electroneurography. Nerve conduction studies are based on the principle of nerve stimulation across the area of interest. In studying the status of the median nerve in the carpal tunnel, the nerve is stimulated proximal to the CL and the compound muscle action potential (CMAP) is picked up by skin electrodes placed over the thenar eminence. The CMAP reflects the status of the motor fibres in the median nerve. The amplitude of the CMAP reveals the number of stimulated motor fibres. The duration reflects the conduction velocities across the different fibres. The latency, between the point of nerve stimulation and the onset of the CMAP, reveals the fastest velocity of the motor fibres across the carpal tunnel (Figure 2).

The sensory fibres of the median nerve can also be studied. Stimulation is done at the same location as for motor stimulation and the sensory nerve action potential (SNAP) is recorded from the distal phalange of the second or third digits. The study of the sensory fibres can be performed orthodromically or anti-dromically (Figure 2).[10]

Abnormalities in the characteristics of the CMAP and SNAP in comparison with normative data previously collected, as well as to the ipsilateral ulnar nerve and the contralateral median nerve, reveal the functional status of the median nerve (Table 1).

Electromyography. Needle electromyography is a complementary rather than a compulsory test in addition to electroneurography. It is usually performed on the median nerve-innervated muscles of the hand and forearm. It reveals the status of the muscle fibres that are dependent on innervation by motor axons. Denervation activity in the electromyogram

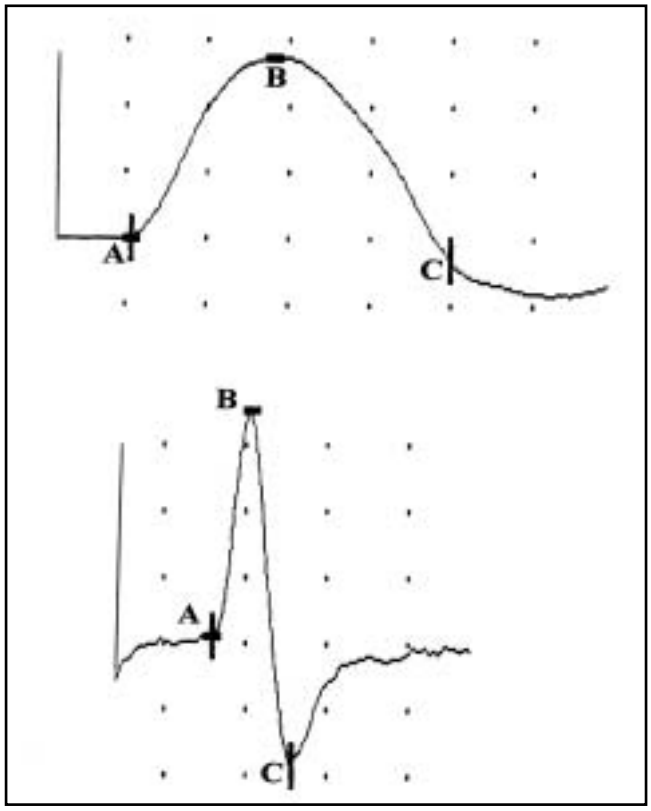


Figure 2. Upper image: the compound muscle action potential or the motor response. Stimulus artefact to A = latency; A to B = amplitude; A to C = duration. Lower image: sensory nerve action potential or sensory response. Stimulus artefact to A = latency; C to B = amplitude; A to C = duration.

reflects recent nerve damage. Neurogenic changes and reinnervation potentials reflect chronic nerve pathology.[11]

Electromyography is also used to reveal other nerve lesions in the involved arm when the neurography findings are not consistent with carpal tunnel syndrome. These include nerve entrapment in the forearm, plexus lesions or cervical root disease.[11]

Electrophysiological tests are sensitive for carpal tunnel syndrome, simple to perform, and cheap, yet often painful. In advanced cases the results may be obvious but in early cases false-negative results are possible. Buch *et al* report that electrophysiological tests confirm a diagnosis of CTS in only 61% of cases suspected clinically to suffer from this syndrome.[12]

We believe that electrophysiological testing should be performed in all of the following circumstances: with any clinical suspicion of CTS; prior to any surgical intervention in the involved wrist; and postoperatively if symptoms persist or recur. The benefits of the electrophysiological tests are numerous and include the following: they confirm or rule out the diagnosis of CTS; they define the degree of entrapment, thereby dictating the mode of therapy; they draw the baseline status of the motor and sensory fibres of the median nerve prior to any surgical intervention; they reveal any intraoperative trauma to, or inadequate decompression of, the median nerve in surgical failures; and they allow the diagnosis of recompression versus failure of decompression in recurrences.

When the electrophysiological studies fail to confirm CTS or reveal another etiology for the patient's complaints, then the diagnosis should be based on clinical grounds. Conservative treatment should be attempted in patients with a high clinical suspicion of CTS even with negative electrophysiological results. On the other hand, one can consider starting a patient on conservative treatment, or administering the first steroid injection without performing any electrical or radiographic studies, if the clinical picture is classical for CTS. If this fails, and prior to surgery, we recommend electrophysiological testing.

Magnetic resonance imaging. Imaging of the wrist has become informative with the recent developments in magnetic resonance imaging (MRI). Axial MRI is the best modality to image the carpal tunnel. It can detect and evaluate chronic nerve diseases, ligamentous and cartilaginous lesions.[13,14]

MRI reveals the status of the median nerve in relation to the surrounding structures. The nerve may be swollen from oedema or flattened by adjacent space occupying lesions. The nerve can look normal on MRI but may be entrapped by fibrous tissue. Pathology in the median nerve appears as hyperintense signals on T2-weighted images.[15,16]

MRI is not yet a routine test for CTS in clinical practice. Despite its inherent advantages of lack of irradiation, free choice of imaging planes, and excellent contrast resolution, it remains time-consuming, delicate, and expensive.[17]

MRI is not essential in clinically or electrophysiologically diagnosed CTS. It becomes important when there is disagreement between the clinical and electrophysiological findings, in patients who do not respond adequately to conservative therapy, and in post-operative recurrences. MRI in unsuccessful surgeries may reveal insufficient sectioning of the flexor retinaculum, or the presence of post-operative fibrosis entrapping the nerve.

Management

The treatment of CTS focuses on decompression of the median nerve in the canal. In mild or moderate cases the decompression can be attained by simple ergonomic modifications, wrist-splinting, anti-inflammatory medications or local steroid injections. In severe compression, surgery is the only therapy.[18,19]

It is reported that around 82% of hands with CTS respond to conservative therapy. Nevertheless, 80% of these will recur after one year, necessitating surgical intervention.[20]

Ergonomic modifications and splinting

The aim of this type of therapy is to avoid repetitive flexion or rotation of the wrist. Hand elevation and non-steroidal anti-inflammatory drugs may be helpful in patients with soft tissue swelling or tenosynovitis. Night splints or braces of the wrist are sometimes helpful in mild cases.[1]

The neutral position of the splint decreases the potential for nerve stretching and thus alleviates the symptoms.[21] The response to splinting should appear within eight weeks of its use. The benefit of splinting depends on the severity of the entrapment rather than the duration of the disease.[21] Severe entrapment does not respond to wrist splinting.

Key points

- Carpal tunnel syndrome is a common disease with sometimes atypical presentation.
- Clinical findings depend on the degree of nerve entrapment.
- Electrophysiological studies are important to confirm or rule out nerve entrapment, as well as to reveal the degree of nerve damage.
- Conservative therapy includes avoiding wrist flexion, night splints, non-steroidal anti-inflammatory drugs, and sub-ligamental steroid injection.
- Surgery is reserved for cases with significant entrapment and can be performed openly or endoscopically.

Steroid injection

Injection of steroids under the CL may decompress the median nerve by decreasing tissue oedema. This is sometimes helpful in moderate entrapment. The needle is inserted at the distal wrist crease, either medial or lateral to the palmaris longus tendon at a 45-degree angle directed distally. A perpendicular approach through the flexor retinaculum is sometimes used but this carries a high risk of injury to the median nerve.[4] The effectiveness of this therapy has not been studied systematically. Clinical experience states that the response usually depends on the degree of compression. In severe cases steroid infiltration is insufficient to relieve the pressure on the nerve. In moderate compression a positive response may be felt several days after the injection, but usually fades away in six months. A second steroid injection is recommended at least six months after the first and only if the response to the latter was clinically satisfactory. When there is the need for a third injection surgical decompression should be seriously considered.

Surgery

Surgical decompression of the median nerve, by transecting the CL, is reserved for patients who do not improve on conservative therapy and in those who present with clinical or electrophysiological evidence of severe entrapment with focal motor or sensory fibre damage.[3] Surgical decompression is performed under regional anaesthesia in the open or endoscopic technique.

Open carpal tunnel release. The incision is around 3 cm long, curvilinear or longitudinal, extending from the palm distally between the thenar and hypothenar eminencies to the edge of the retinaculum proximally. The entire flexor retinaculum is transected under direct vision. Some of the complications of this surgery include scar formation and cutaneous neuralgia.[3,22] Recurrences after open surgery are rare and usually the result of incomplete transection of the flexor retinaculum or iatrogenic trauma to the median nerve.[23,24]

Endoscopic carpal tunnel release. This was introduced in 1989 by Okutsu and colleagues to reduce the morbidity of surgery and hasten recovery. There are two endoscopic techniques: the one-portal release system and the two-portal release system.[25]

A multi-centre, prospective, randomised study comparing the open and endoscopic carpal tunnel release operations revealed similar success rates in symptom relief and patient satisfaction. The open technique produced more scar tenderness, while the endoscopic technique caused more nerve injury.[26]

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